DISCUSSION BEFORE THE RADIO SECTION, 5TH NOVEMBER, 1947

Dr. R. C. G. Williams: The subject of the paper is of great importance to the British radio industry, particularly in view of the present intensive export drive, as one of the qualities which help to sell British products on the world's markets is reliability.

I have recently had the opportunity of seeing something of the radio industry in the United States, an industry which is likely to be one of our strongest competitors in the export field, and it may be interesting to draw a few comparisons. American products are attractively marketed generally at prices lower than hold in this country, but there are other factors of which we might well take advantage. The marketing, promoted by large-scale and attractive Press and radio advertising, while particularly suited to an American buyer, is not necessarily the best way of selling here, or in fact in those many countries in the world where there is what we call the British way of life. In this country, while we are naturally to some extent swayed in our choice by advertising, our final decision is normally based on a somewhat critical examination of the product and a fairly close cross-questioning of the retailer on its performance, expectation of life, and servicing facilities. On the other hand, the American buyer's decision is based much more directly on the advertising story and the immediate appeal of the product. American prices are lower mainly because of much more freely available and cheaper raw materials and production on a much larger scale. These basic reasons for lower cost are inherent in our respective economies and must perhaps be regarded as a more or less permanent disadvantage with which our industry is faced, but this can be more than offset by a proper appreciation of the requirements of the buyer and by making use of the greater knowledge and experience which we have of reliability and the manufacture of articles of long and trouble-free life.

The Englishman regards his radio set as a capital item, while

the American regards his more as a consumable item and is influenced primarily by its initial attraction and performance, with less regard for how it will perform and look in five or ten years' time and what will be the cost of maintenance in the interval. This attitude is naturally followed by American manufacturers, and in my experience they pay less attention to questions of component reliability than do British manufacturers. The same attitude is shown in radio servicing. British manufacturers invariably take a keen interest in the life of their sets after they have been sold, and repairs here are cheaper and, in general, more thoroughly carried out than in the United States.

I should be interested to know whether the author has had an opportunity of making any sort of comparative tests on bulk samples between American-made components and their English equivalents. It would also be useful to have some reference to any work which has been published on valve reliability. In earlier days, the valve was thought to be the most unreliable component in the set, and hence was plugged in so that it could be easily replaced. While now in this respect the volume control and the electrolytic condenser are perhaps the most critical components, it is still the valves which figure most prominently in export servicing considerations.

In Section 1, the author speaks of a period of five years which most of the tests are arranged to simulate, but I think that it would be wise to increase that period. Five years is a commonly accepted design figure for set life, but, aside from practical experience which tends to a ten-year life, it would in any case be prudent to aim at a longer life for each individual component, to provide a factor of safety.

Regarding the reference in Section 2.1 to some tests on rubber, would it not have been simpler to define the change in thickness as 25% of the thickness rather than as 50% of the half-thickness?

With reference to Section 2.2, I should have thought that, in the course of ten years, the accidental hazards of the external part of the cabinet are far greater than the abrasive effect of the dust, even with the most conscientious dusting such as the author describes.

In Section 2.2, there is a reference to the assessing of wear on gramophone records by observing the "greying" of the surface. While this is the first reference which I have seen to this method, I have noticed that a very noticeable "greying" is seen on a used record if it is tilted at the proper angle to the light, and I should be interested to hear just how reliable is this most convenient and rapid check.

Chemical tests, perhaps more than any other, make it possible to investigate the properties of the material of a component sufficiently to synthesize the predicted life and direct its design evolution in a more knowledgeable way.

Section 5.1 deals with noise tests on volume controls, which, as already mentioned, are among the more vulnerable components. I think that it would be highly undesirable for any radio manufacturer to use Make A in his radio set, and it is in some ways a pity that the rules of The Institution enforce anonymity. The same comment applies to Make D of the vibrator and Make B of the unbleached cotton tape.

The tests on dipping, referred to in Section 5.5, bring out extremely well the indispensability of dipping after impregnation. In all those cases, no matter what type of wax is used, it is striking what a difference the additional dip makes.

Mr. P. R. Coursey: The paper is of value to component manufacturers as it gives not only a frank exposition of the user's point of view, but also a comprehensive picture of the type of tests which he, as a user, thinks necessary. Most users have their own ideas in this connection, and I should like to enter a plea for a greater attempt at standardization of the type of such tests, even if the details of the exact limits imposed in the tests are left to individual choice. The commercial viewpoint given by the author is necessarily different from that of the Services, who have already achieved a considerable measure of unification of tests. I consider it important to note that the author has adopted some of the Service tests, since this is helpful to component manufacturers, who have already accumulated a great deal of data on such tests and have, in consequence, experience of the performance of their manufactures under such tests.

The duration of life that should be stipulated for any component is always debatable, particularly for intermittent usage such as in broadcast receivers. The figures of about 5 000 h, given by the author, are of the same order as that of 10 000 h quoted by Dr. Williams, but I consider the latter figure nearer to the practical requirements; it also fits nicely as an intermediate value between the 1 000 h specified for war-time Service equipment, and the 100 000 h that is the minimum usually required for continuous industrial uses. I endorse Dr. Williams's emphasis on the importance of reliability for British-made components, even though this may sometimes mean that such components cost rather more than if they were made by American mass-production methods.

The author's recorder for temperature-coefficient measurements is most interesting, but I suggest that the rate of change of temperature must be made appropriate to the thermal capacity of the component under test, as otherwise meaningless intermediate values and wrong calculated coefficients will be obtained. Concerning life tests, I suggest it is useful to make tests at approximately logarithmic intervals and to plot the results as percentages of failures (or percentages of components passing the tests) on a logarithmic time-scale.

Most of the author's test values are reasonable; I think, however, that his 10-lb minimum-pull test is too high, particularly for present-day materials with dollar restrictions. Would not the combined tension and bending test at a much lower pull, which is now being included in the Inter-Service Specifications, be better? For the insulation tester, a maximum capacitance limit (of about 1 μF) must be specified, or the 2-megohm series resistance will vitiate the results. The conductivity test for tapes, etc., is welcomed, as the commonly used acidity test is frequently inadequate.

Mr. J. H. Cozens: In Section 4, dealing with chemical tests, the author refers to the testing of waxes, but several tests must be made in addition to those mentioned to ensure that a wax will be satisfactory. The melting point and electrical properties must naturally be measured, and less obvious tests, such as those for mechanical stability and seepage of plasticizers, should also be carried out.

A simple test which I have found very useful in selecting waxes consists of casting a cone of wax 1 in high and 1 in base diameter and standing it on a Whatman No. 1 filter paper in a temperature-controlled oven for six hours at the maximum temperature at which the wax will be required to operate. The mechanical stability of the wax can be assessed by observing the decrease, if any, in the height of the cone, and any low-melting-point constituent liable to seep out in service will be absorbed by the filter paper; the area of the resulting stains can be measured and recorded. In another test, the molten wax is poured into a small metal tray measuring 2 × 1 × ½ in deep and allowed to cool slowly. The wax contracts as it changes from the liquid to the solid state, and, if the adhesion to the metal surface is not good, the edges of the wax may pull away from the metal. Some idea of its usefulness as a sealing compound can thus be obtained. If the tray is then stood on end in a temperature-controlled oven, a further measure of the mechanical stability is obtained from the distance through which the upper edge of the wax falls.

On the question of the test for free sulphur in rubber, the

author states that sometimes a sample is found which, although showing a high sulphur content by the B.S. 903 test, appears to have a low sulphur content when judged by the silver-staining test, and he therefore prefers the B.S. 903 test. I prefer the silver-staining test because the object of the test is to ensure that the rubber will not cause premature tarnishing of any neighbouring silver switch-contacts, and the direct method, which actually shows the extent to which tarnishing takes place under accelerated conditions, must surely be the best guide.

With regard to Section 5.5, I note that the tests on wax-dipped coils were of only six days' duration. In Section 4.2, the author rightly points out the inadequacy of short-time accelerated humidity-tests, and for this reason I should be interested to know whether, if the humidity tests on the coils were prolonged, the superiority of the impregnated and wax-dipped specimens over the undipped specimens would be maintained. I should expect them all eventually to have an equally low Q-factor.

Mr. E. M. Lee: Mr. Coursey has already implied that if every set maker devised as thorough a series of tests as the author's, each working on his own, life would become very difficult for the component makers. If other set makers thought along the same lines as the author, it would be well for them to co-operate with component makers to obtain a certain degree of standardization, but I should not like to see the extreme position here which has arisen in some countries. Ten or eleven countries on the Continent have formed an organization of this kind, but it is not the set and the component makers who determine what they think are satisfactory and economical commercial components. Here matters seem to be decided by insurance companies, the electricity supply undertakings, Government Departments, a few university professors, etc., and industry is merely consulted. Most stringent rules were laid down, which are a real handicap to some of our component and set makers who are engaged in export business.

Their tests, which differ from ours, are not all stupid; in some countries, such as Norway and Switzerland, many people live in wooden houses, and if a radio set caught fire the result would be more serious than in this country, and it is understandable that they have more stringent regulations aimed at avoiding fires. On the other hand, our houses are more conducting, so that we have more severe regulations with regard to earthing.

Some of the tests in Continental countries were standardized to an extreme degree and too rigidly maintained. For example, an Izod-type test was specified for moulded switch covers, on to which a weight came down on a pendulum of a certain length and hit the switch cover in a certain fixed place a certain number of times. After a time, it was found that some manufacturers had put stiffening fins inside the moulding just where they knew that the hammer was going to fall.

I think that, if we had waited for standardization of tests for commercial radio components on the scale which has been adopted for Service components, it would have been a slow process. The author was quite right in going ahead on his own and devising his own tests, and I hope that many other set makers have done so, because the work they do and the experience that they gain will be extremely valuable when we make a start on standardization of tests in the domestic radio field.

I should like to know what other set makers have developed, and whether they are on lines similar to the author's or entirely different. I think that it would be very valuable if set makers and component makers who are using tests of this sort for domestic radios were to have that information published abroad in overseas technical journals, to bring it to the notice of the radio engineers, radio dealers and radio service men in the various countries. I am sure that it would go a long way towards convincing them how careful we are in the construction of our sets, in spite of the fact that we are not members of the Continental testing organization to which I referred.

Dr. R. S. Vincent: I propose to confine my remarks almost entirely to the chemical tests dealt with in Section 4. In Section 4.1 the author describes the B.S. 903 test for sulphur by the nitric-acid method, but he does not mention that there are difficulties in interpreting the results of this test, since, as I understand the matter, it gives an intermediate answer between the free and the total sulphur in the material. These difficulties of interpretation are increased when the compound contains factice or a thioplast type of material.

At the R.A.E., in trying to select a suitable material for quartz-crystal gaskets we were unable to find any correlation between the results of the B.S. 903 test and the behaviour of the gasket materials as regards their tarnishing of the plating on quartz plates, whereas with the iodine-azide test good correlation was obtained. The explanation may be that we were concerned with extremely small quantities of sulphur, smaller than those which normally caused concern. In the course of this work, an empirical test was developed in which one of the silvered quartz-plates was enclosed in a test-tube and surrounded by fragments of the gasket material, and kept at 100° C for 100 hours. This was a very severe test, but materials were actually found which gave no tarnishing of the plating whatever.

The silver-staining test, as described in the Radio Component Standardization Specification 310, has the advantages that it is simple and can be carried out easily in any electrical laboratory. I have found that samples of rubber which give a good result on this silver-staining test also give good results in oxygen-bomb tests, or after long exposure to humidity cycles. With this experience in mind, I should be very reluctant to abandon the silver-staining test, as described in the R.C.S. specification.

Mr. R. H. Wilson: I agree with Mr. Lee in wishing that set makers, rather than component makers, were contributing to the discussion.

Humidity tests are referred to in the paper only briefly (in Section 4.2), and I feel that the author might have given a little more detail in this connection, particularly in view of the increasing emphasis on export markets.

The determination of the noise level in volume controls is a problem which has been with us for a long time, but no very marked degree of agreement has been reached. The author's circuit and test figures are extremely interesting to me, because they agree very closely with some figures which we obtained with a set made by his company. We found that this particular set required a noise level of 3 mV/V to produce a noise which was just audible, so that the author's acceptance figure of 2·5 mV/V fits in with that very well. Our maximum pass level in production testing is 1 mV/V. Typical noise records obtained from linear and logarithmic-law potentiometers show levels of the order of 0·5 mV/V and illustrate how the noise level varies with the resistance of resistors of the logarithmic-law type, being extremely low over the low-resistance portion most commonly in circuit at low volume levels.

In connection with the circuit and test method which the author has shown, I should like to refer to what I feel are danger spots which might lead to somewhat misleading results. A fairly obvious one is the speed of rotation of the control. The more rapidly a control is rotated, the larger is the amount of noise, but another factor appears, namely the variation of the d.c. potential brought about by the, say, 20 volts across the track. If the control is rotated sufficiently rapidly, and if the input-circuit conditions are suitable, it is possible to transmit into the amplifier an effect due to the d.c. loading which tends to swamp the noise. I should be interested to hear how the author controls his rotation speed of 30 cycles/min. Another difficulty is that of

frequency response, particularly concerning the input filter consisting of condensers and resistors. We have found that, unless the filter characteristics are sufficiently good, we get severe trouble due to this d.c. component, so that it is necessary to have a very appreciable attenuation below about 300 c/s, to prevent this misleading result. Regarding the detector constants in the circuit and the relationship between the peak, the nuisance value and the average values of noise, I agree that a fast rate of rise and a fairly lengthy decay are required; with this relay-operated device there is the danger, however, which the author may already have experienced, that a single peak of fairly large magnitude may trip the relay, although that single peak by itself would probably have a negligible nuisance value in the control.

Regarding the testing of the fixed-composition resistor, the author refers to overload tests of a drastic kind, and further details of his experience of "clouds of gas," "fire" and "explosive violence" would be appreciated.

Mr. M. G. Scroggie: Mr. Coursey has advocated standard acceptance tests for components; these would obviously be attractive to the supplier of the components, because he would have to provide against only one form of test, which he would know. Mr. Lee has pointed out, however, the drawbacks which may arise from such a policy. It has also been mentioned that even test procedures which have reached the stage of becoming British Standards have not all proved to be completely safe, and I therefore suggest that there is something to be said for manufacturers devising their own tests. There is the risk that some tests may be unreasonable or unsuitable, but a variety of tests, arrived at independently, are more likely to cover all the hazards.

I wish the author had explained a little more fully his statement in Section 2.1 that tests (*b*) and (*c*) on gramophone pick-ups are closely connected. If it is a question of groove holding, it is not obvious that these static tests are valid for the dynamic conditions of actual use. I should have expected the inertia of the head to require consideration, and I wonder what assumption the author has made with regard to the coefficient of friction.

I am interested in the author's dusting test, and should like to know how the abrasive dust was periodically applied; it seems to be very difficult to simulate the actual conditions, and the results of the tests depend rather critically on the precise way in which the dust is applied and what sort of dust is used.

Referring to Section 2.2, dealing with the testing of tuning controls, I wonder why it should be necessary to use tuning controls in this way under the conditions of life stated. Even if it is assumed that it is perfectly easy to provide tuning controls which will stand up to operation over a wide range of 3 650 times a year, why should the owner of the set be condemned to unending repetition of an irritating, time-wasting, and wholly unnecessary process demanding skill and attention? In the vast majority of homes, changing between Home and Light programmes is the only tuning frequently performed, and all that is needed for that is a switch.

As the paper is not strictly confined to methods of tests, but also gives some very illuminating test results, perhaps the author could supplement this information by enlarging on the subject of gramophone-record wear. Little has been published on the relative wearing effects of different needle points, and many of the results that have appeared are contradictory. It would be interesting, therefore, to have some results of tests using different needle points, e.g. sapphire, steel, and fibre.

Mr. E. L. E. Pawley: No mention is made in the paper of shelf life. It seems to me that for components such as electrolytic condensers this may be important. In the paper, figures are given which show the deterioration suffered by electrolytic condensers after 5 500 hours' use. With a domestic radio receiver, that may represent about five years of life, but in five years there are 43 800 hours, and I should like to ask whether the effect of the 38 300 hours of idleness may not, in fact, in some instances be more damaging to the electrolytic condensers than the 5 500 hours of work.

Mr. N. G. Westcombe: I am interested in the author's peak-load and overload tests, and I have compared these with those called for in Inter-Service Components Specification No. 132 for mica-dielectric capacitors. The author uses a direct load of 10 lb on the wire or tag; whereas the specification prescribes a maximum pull of 5 lb. I wonder why it is necessary for commercial equipment to require a more stringent test than is deemed desirable for Service equipment, where the conditions are extremely severe. On the other hand, the author's bending test is much less severe than the Specification No. 132, as he does not favour the application of an axial load simultaneously with the bending test. I do not share Mr. Coursey's view, however, that the test is vague, and I think that it has a great deal to commend it.

The soldering test is more severe than that required by the Services, who specify the use of a 120-watt soldering iron with a bit at 250° C placed in contact within $\frac{1}{4}$ in of the capacitor for 15 sec, whereas the author uses a test based on keeping the component in molten solder for 15 sec at 300° C.

I was glad to note that the author is of the opinion that the long-term humidity-test is more representative than a short-term accelerated test. There does not seem to be uniformity of opinion on this matter, however, because another large manufacturer specifies a test similar to the well-known K 110 test, but with a dry-heat cycle at 60° C and two humid cycles of 42° C with 95–100% relative humidity.

The comparisons which I have made between what the author considers adequate and what other authorities require show a need, in my view, for a greater measure of standardization of test procedure throughout the industry, and I concur with the view expressed by Mr. Coursey and others that something should be done about the matter.

In Section 5.5 the author has made no comments on the performance of the wave-wound coils under tropical conditions. It is extremely interesting to note, as a previous speaker has mentioned, that vacuum impregnation does not appear to give satisfactory protection by itself, and that a subsequent dip in wax of a satisfactory type and under specified conditions is essential. Our experience has been the same with capacitors, and we have found that the time of dipping and the temperature of application are extremely important if a satisfactory product is to be obtained.

I found the description of the apparatus which the author uses for temperature-coefficient measurements very interesting, but I am surprised to see from his chart that he carries on this test for two hours. In the apparatus which we have developed, which is based essentially on a beat-frequency method, the change of frequency is translated into a change of capacitance by adjustment of a micrometer capacitor which brings the beat frequency back to zero. Measurements on capacitors of the silver-mica and silver-ceramic types do not take longer than about 15 min.

[The author's reply to the above discussion will be found overleaf.]